THE
OHIO JOURNAL OF SCIENCE
PUBLISHED BY THE
OHIO STATE UNIVERSITY SCIENTIFIC SOCIETY

VOLUME XVIII JUNE, 1918 No. 8

TABLE OF CONTENTS

THE PARASITES OF LEAF-HOPPERS.
With Special Reference to Anteoninæ.

F. A. FENTON.

PART III.

THE EFFECT OF PARASITISM ON THE HOST.

There has been comparatively little work done in regard to the internal or cytological changes in the insect host brought about by its parasite. Giard (1889) in working out the biology of *Aphelopus melaleucus* parasitic on *Erythroneura (Typhlocyba) hippocastani*, misinterpreted the real nature of the larval sac, supposing that it was a true animal gall, "formed by a gradual dilation of the hypodermis which secretes an abnormal cuticle * * * " He proposed the name *thylacies* to those galls produced in animals comparing the typhlocybid larval sac with the tumors caused by Cuterebra on the skin of mammals. He compared the genitalia of normal and parasitized *E. hypocastani* and *E. douglasi*. In the females of these two species the ovipositor in parasitized individuals is greatly reduced and functionless. In the males of *E. douglasi* very little change is brought about in the penis which is comparatively simple, but in *E. hippocastani* where this structure is a very complex eight-branched organ it is reduced to six or even three branches, thus greatly affecting the specific characters. Because of this superficially it might be confused with *E. rosæ*. Certain accessory sex organs were also found to be affected by the dryinid.

Marchal (1897) studied in detail the pathological conditions that *Trichacis remulus* Walk. produced in its host *Mayetiola destructor*, the Hessian fly. He observed that the *Trichacis* larva is always in intimate connection with the nervous system of the cecidomyid larva and he noted the remarkable cell proliferations that are brought about by the parasite. Although he did not find the early stages and therefore was unable to state anything about their origin, he made some striking conclusions, saying that "These groups of giant cells are evidently destined to accumulate nutritive materials necessary for the parasite. They are a kind of internal animal gall developed by the presence of the Hymenopteron."

Keilin and Thompson (1915) noticed the peculiar mass of hypertrophied tissue formed within *Erythroneura hippocastani* parasitized by *Aphelopus melaleucus* and traced its origin to the hypodermal cells which are stimulated to abnormal growth by the presence of the parasite. The early stages of the dryinid were found to be enclosed by this tissue similar to that in the *Trichacis* larva, shutting the parasite off from the viscera of the host. This cyst was noticed to be surrounded by a membrane which persisted after the parasite larva had assumed the curved position and had broken through to the exterior of the host. They believe that the parasite draws its nourishment from its host through the cyst membrane until the fifth stage is reached, and that the tissue is not a phagocytic cyst. They compare the cyst to the placenta in animals or to a vegetable gall and term the parasitism "*placentaire*" or "*gallicole.*"

Kornhauser (1915-16) in studying the effects of *Aphelopus* parasitism on *Thelia bimaculata* observed marked changes in the external characteristics of the sexes, especially in the size and form of the male and a reduction of the external genitalia of both sexes, stating that "the presence of parasites in the male nymph brings about lower oxidation, storing of fat, retarded rate of development, increased size; and with this change in metabolism comes a change in some of the secondary sexual characters. But changed metabolism is not powerful enough to change the external genitalia, it merely reduces them in size."

In studying the effects of the parasitism of *Aphelopus comesi* on *Erythroneura comes* the writer was able to confirm many of Keilin and Thompson's observations and to add a number of interesting points. The early phases were not studied

owing to a lack of material, but comparisons of the later stages of parasitism in these hoppers with normal individuals were made. When the dryinid is in its second instar and has become partly external the hypertrophied tissue has reached its maximum size (Plate II, Fig. 2). It is seen as a large ovoid mass of cells occupying most of the body cavity in the hind thoracic and anterior abdominal regions, displacing and pushing backwards the large storage stomach of the host. It extends for three somities as a rule, its anterior extremity lying between the muscles of the third thoracic segment. It is in intimate connection with the point of attachment of the parasite. In cross section the thin membrane surrounding it can be seen, except at that part nearest the parasite, where the cells of the cyst are in contact with the mouth parts of the latter, (Plate IV, Fig. 3).

In the earliest stages studied the cell walls and nuclei are sharply defined and part of the tissue is composed of dividing cells, (Plate IV, Fig. 2; Plate VI, Fig. 1). The cells are filled with food globules and are vacuolated. Later division ceases and the cells become more noticeably vacuolated, (Plate IV., Figs. 3 and 4). Late in the fourth instar of the parasite disintegration of the cells begins, (Fig. 5, Plate IV, Figs. 3 and 4). The cell walls are broken down, the nuclei become disintegrated and the protoplasm becomes very largely filled with round vacuoles. Directly after the fourth molt of the parasite this cyst is attacked first and devoured after which the host viscera are devoured.

The cyst stains easily with Delafields haemotoxylin, being thus sharply contrasted with the surrounding tissues which take the eosin stain more readily. It reacts to stains similarly and resembles fatty tissues.

The function of such a cyst is problemmatical. It is not found in a great many other insect hosts of *Hymenopterous* parasites and has not been observed in any other genus of the *Anteoninæ* so far. It cannot be phagocytic because the mandibles of the parasite are not developed or are functionless until the last larval molt, and it is not absorbed. Except for cytoplasmic changes it remains unchanged until the fifth instar is reached by the dryinid. It doubtless serves as a means for absorbing, storing up, and then in turn giving up in a modified manner food for the parasite that otherwise would have been utilized by the host. This food is probably absorbed from the blood of the hopper through the cyst membrane.

This hypertrophied tissue is developed principally at the expense of the gonads of the host, (Plate III, Figs 1 and 2). These are lacking or almost so in parasitized individuals. The digestive system is also modified to some extent in that the storage stomach is forced backwards and displaced by the abnormal tissue. The malpighian tubules are much smaller in parasitized individuals. Normally these are large and much swollen, in parasitized specimens they are hardly enlarged at

Text Fig. 5. Hypertrophied tissue in dryinized male *Erythroneura comes* (high power).

all. When the parasite pushes apart the abdominal somites and begins to grow outwards the cavity thus formed in the body wall is enlarged until it becomes almost circular. Around this cavity a layer of hypodermal cells is developed as an abortive response by the host tissues to heal over the wound, (Plate IV, Figs. 2 and 4).

No other host was studied in as much detail in regard to the cytological changes as was the above. However it is certain that in the case of *Gonatopus contortulus* parasitic on *Deltocephalus sayi*, (Plate VI, Fig. 2), there is no such development and from general dissections of all the other species studied in

this paper no such tissues were found. Since many Cicadellid species are attacked and parasitized by dryinids after they have become sexually mature it is doubtful in these cases whether the gonads would be completely disintegrated. In fact in parasitized *Deltocephalus sayi* they are present, but modified in that the germ cells are not matured after a certain point is reached in the parasites growth, so that if reproduction is not entirely stopped it is greatly impaired.

In *Erythroneura comes* the hypertrophied tissue is probably caused by a stimulation set up by the presence of the parasite in the host's tissues or to some toxic substance secreted by it. That the sting alone will not produce such a result is proved by the fact that hoppers that have been stung but not oviposited in develop and mature in a perfectly normal manner.

A comparison of the genitalia of both sexes in *Erythroneura comes* in normal and parasitized individuals showed no differences.

CONCLUSIONS.

1. The larva of *Aphelopus* species secretes some toxic substance into the tissues of the host or otherwise stimulates the abnormal development of the hypodermal tissues into a hypertrophied cell mass.
2. This is developed at the expense of the gonads which do not develop upon the maturity of the host.
3. This is surrounded by a membrane and functions as a means of absorbing food from the body of the host for the parasite and is itself not consumed until just before the death of the host.
4. The genitalia of the host are not modified by the parasite.
5. A wall of cells is developed around the wound produced in the body wall of the host.
6. The malpighian tubules of the host are underdeveloped.
7. *Gonatopus*, *Haplogonatopus*, and *Chelogynus* species that parasitize nymphs stop further development of the host which does not become mature.
8. Adults parasitized by these genera, that have become sexually mature, may still reproduce at first but there are evidences that soon reproduction is greatly impaired or entirely stopped.
9. The hypertrophied tissue has not been found produced by any genus other than *Aphelopus*.

BIBLIOGRAPHY.

ASHMEAD, W. H.—Monograph of the North American *Prototrypidæ*. Bulletin U. S. National Museum, 45, pp. 80-102, 1893.

BRUES, C. T.

Descriptions of New Ant-Like and myrmecophilous *Hymenoptera*. Transactions American Entomological Society, Vol. 29, p. 125, 1903.

————Some New Species of Parasitic *Hymenoptera*. Canadian Entomologist, Vol. 36, pp. 117-119, 1904.

————Notes and Descriptions of North American Parasitic *Hymenoptera*. Wisconsin Natural History Society, Vol. III, pp. 183-185, 1905.

————Notes and Descriptions of North American Parasitic *Hymenoptera*, Number 11, Wisconsin Natural History Society, Vol. IV, p. 143, 1906.

————Notes and Descriptions of North American Parasitic *Hymenoptera*, Number V, pp. 101-102, 1907.

————Some Notes on the Geological History of Parasitic *Hymenoptera*. Journal New York Entomological Society, Vol. XVIII, No. 1, pp. 1-16, 1910.

————Drynidæ, in *Hymenoptera* of Connecticut. Connecticut State Geological and Natural History Survey. Bulletin 22, pp. 613-616, 1916.

BRADLEY, J. C.—Contributions to the Entomology of the Selkirk Mountains of British Columbia. Canadian Entomologist, Vol. 38, p. 380, 1906.

GIARD, A.—Sur une galle produite chez le *Typhlocyba rosæ*, par une larve *d'Hymenoptera*. Comptes Rendus, Ac. Sc. Paris, CIX, pp. 79-82, 1889.

————Sur la castration parasitaire des *Typhlocyba* par une larve *d'Hymenoptere* (*Aphelopus malaleucus* Dalm.), et par une larve de *Diptere* (*Ateleneura spuria* Meig.). Comptes Rendus, Ac. Sc. Paris, CIX, pp. 708-710, 1889.

HALIDAY, A. H.—Notes on the *Bethyli* and on *Dryinus pedestris*. Entomologists Magazine, Vol. 2, pp. 219-221, 1834.

HOOD, J. D.—Notes on the Life History of *Rhopalosoma poeyi* Cresson. Proceedings of the Entomological Society of Washington, Vol. XV, No. 4, pp. 145-148, 1913.

KEILIN, D., AND THOMPSON, W. R.—Sur les larves des *Dipteres* et *Hymenopteres* des *Typhlocybes*. Comptes Rendus des Seances de la Societe de Biology, T. LXXVIII, pp. 1-9, 1915.

KIEFFER, J. J.—Family *Dryinidæ*. Genera Insectorum, Fasc. LIV, 1907.

————Monograph of the *Bethylidæ*. Das Tierreich, 41 Lieferung, pp. 1-22, 1914.

KORNHAUSER, S. J.—Changes in *Thelia bimaculata* (Fabricius) Induced by Insect Parasites. Abstract Amer. Soc. of Zoologists, Columbus, Ohio, 1915.

————Further Studies on Changes in *Thelia bimaculata* brought about by Insect Parasites. Anatomical Record, Vol. 11, No. 6, pp. 538-540, 1916.

MARCHAL, P.—Les *Cecidomyies* des Cereales et leurs Parasites. Annales de la Societe Entomologique de France, pp. 1-105, 1897.

MIK, J.—Zur Biology von *Gonatopus pilosus* Thoms. Wiener Entomologische Zeitung, 1, pp. 215-221, 1882.

MISRA, C. S.—The Indian Sugar-cane Leaf-hopper *Pyrilla aberrans* Kirby. Memoires of the Department of Agriculture in India, Vol. V, No. 11, 1917.

PATTON, W. H.—Descriptions of Several New *Proctotrupidæ* and *Chrysidæ*. Canadian Entomologist, Vol. 11, p. 65, 1879.

PERKINS, R. C. L.—Leaf-hoppers and their Natural Enemies. (Part I, *Dryinidæ*). Report of Work of the Exp. Sta. of the Hawaiian Sugar Planters Association, Bull. 1, part 1, 1905.

————ibid. Bull. 1, part 10, pp. 483-494, 1906.

ibid. Bull. 4, pp. 1-55, 1907.

————ibid. Bull. 11, pp. 5-17, 1912.

VAN DUZEE, E. P.—Catalogue of the *Hemiptera* of America North of Mexico. University of California, Technical Bull. Vol. 2, 1917.

SWEZEY, O. H.—Observations on Hymenopterous Parasites of Certain *Fulgoridæ*. Ohio Naturalist, III, pp. 444-451, 1903.

————Observations on the Life History of *Liburnia campestris* with Notes on a Hymenopterous Parasite infesting it. Bull. U. S. B. E. 46, pp. 42-46, 1904.

EXPLANATION OF PLATES.

EXPLANATION OF PLATE I.

Fig. 1. *Gonatopus erythrodes*, female.
Fig. 2. *Phorbas mirabilis*, male.
Fig. 3. *Aphelopus dikraneuri*, male.
Fig. 4. *Phorbas mirabilis*, female.
Fig. 5. *Gonatopus erythrodes*, male.
Fig. 6. *Chelogynus osborni*, female.
Fig. 7. Chela of *Gonatopus erythrodes*.
Fig. 8. Chela of *Haplogonatopus americanus*.

EXPLANATION OF PLATE II.

Fig. 1. Normal male *Erythroneura comes*.
Fig. 2. Parasitized *Erythroneura comes*.
Tes., testes; sto., storage stomach; hyp., hypertrophied tissue; par., parasite, fourth instar.

EXPLANATION OF PLATE III.

Fig. 1. Parasitized male *Erythroneura comes*, longitudinal section.
Fig. 2. Normal male *Erythroneura comes*, longitudinal section.
par., parasite, fourth instar; hyp., hypertrophied tissue; tes., testes.

EXPLANATION OF PLATE IV.

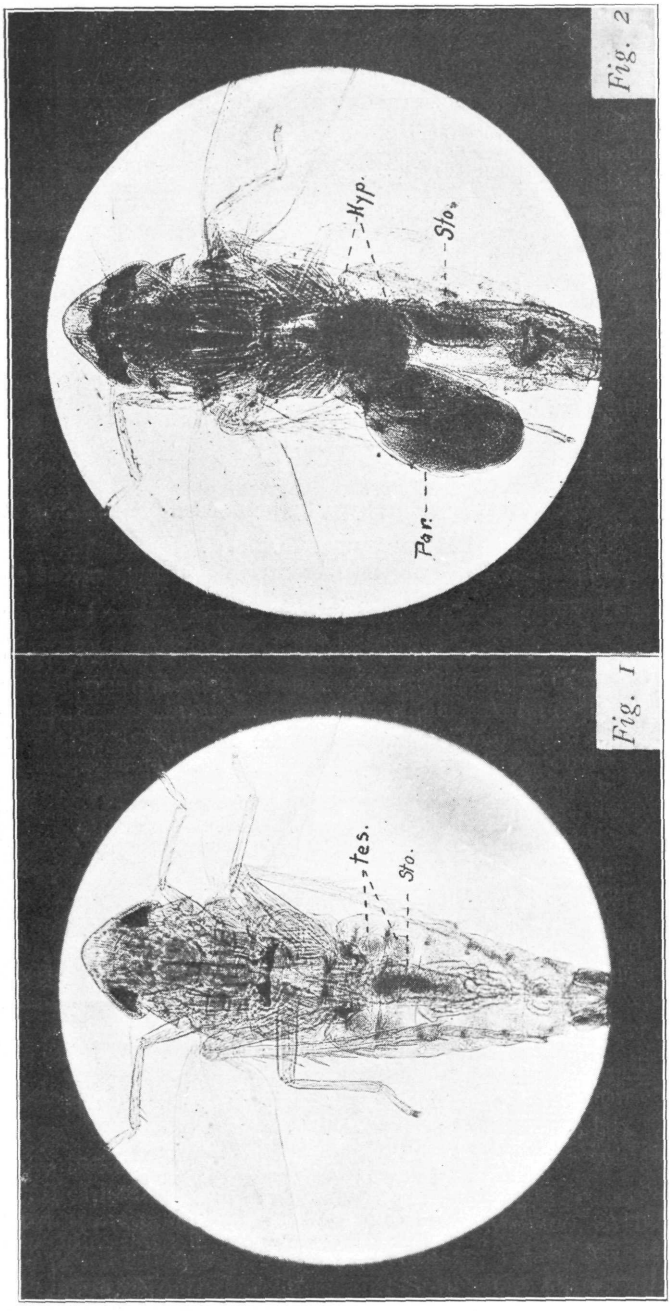
Fig. 1. Normal male *Erythroneura comes*, cross section through second abdominal segment.
Fig. 2. Parasitized female *Erythroneura comes*, showing nature of hypertrophied tissue in early phase, cross section through second abdominal segment.
Fig. 3. Parasitized male *Erythroneura comes*, showing nature of hypertrophied tissue in late phase, cross section through point of attachment of parasite on first abdominal segment.
Fig. 4. Parasitized male *Erythroneura comes*, cross section of same individual as Figure 3, through head of parasite on second abdominal segment.
Sto., storage stomach; tes., testes; hyp., layer of hypodermal cells developed around the wound produced in the host by the parasite; par., parasite; es., esophagus; hyp., hypertrophied tissue; ch., heavy layer of chitin at point of attachment of parasite.
Camera lucida drawings, ocular 7.5, objective 16 mm., Spencer Microscope.

EXPLANATION OF PLATE V.

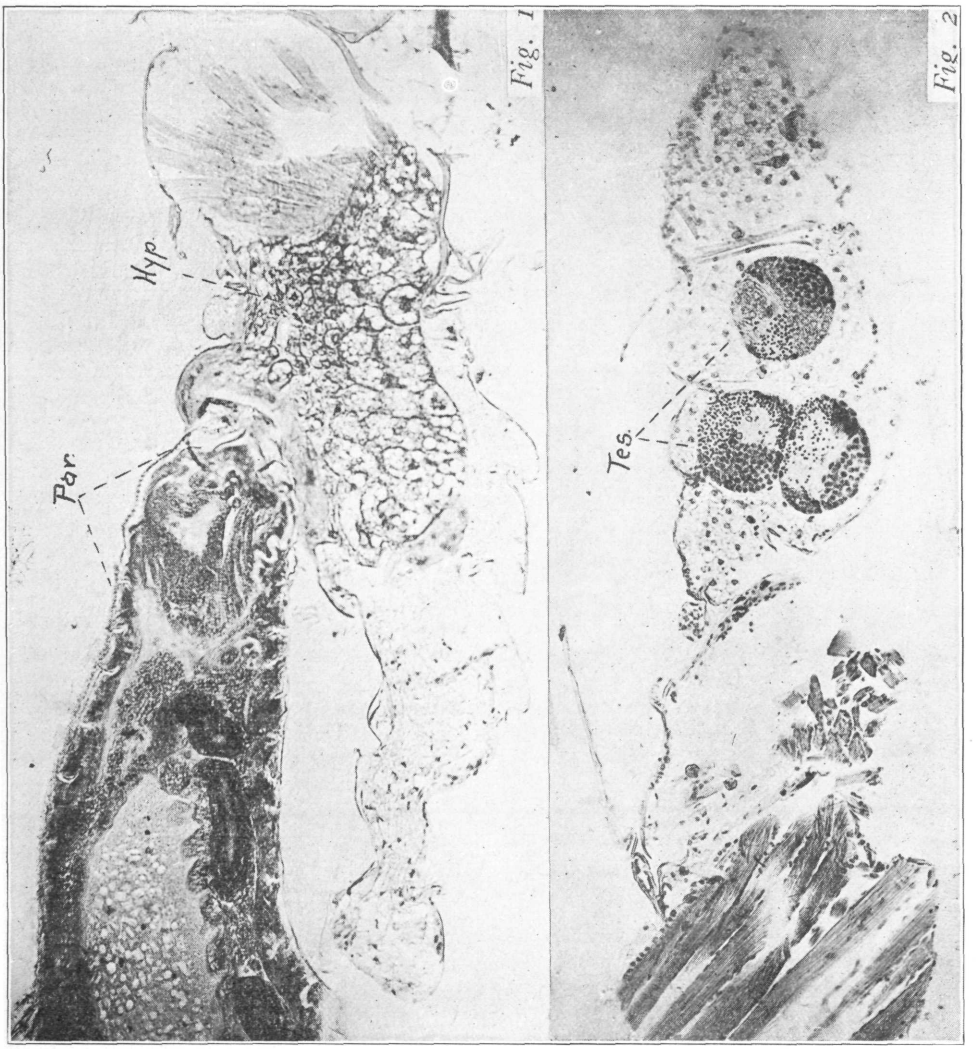
Fig. 1. Normal male *Erythroneura comes*, cross section through second abdominal segment.
Fig. 2. Parasitized male *Erythroneura comes*, cross section through metathorax, showing extreme anterior part of parasitic cyst.
Fig. 3. Parasitized female *Erythroneura comes*, cross section through first abdominal segment just before attachment of parasite.
Fig. 4. Parasitized male *Erythroneura comes*, cross section, third abdominal segment.
Sto., storage stomach; tes., testes; hyp., hypertrophied tissue; gon., rudiment of ovary; par., parasite.

EXPLANATION OF PLATE VI.

Fig. 1. Parasitized male *Erythroneura comes*, cross section through second abdominal segment at point of attachment of parasite.
Fig. 2. Parasitized male *Deltocephalus sayi*, longitudinal section through testis showing atrophy of this structure and disintegration of surrounding tissues. This individual was dying from the effects of parasitism at the time of fixation, the parasite being in the last stage.
Es., esophagus; hyp., hypertrophied tissue; m., membrane surrounding cyst; par., parasite; tes., testis; int., intestine.



F. A. Fenton



F. A. Fenton

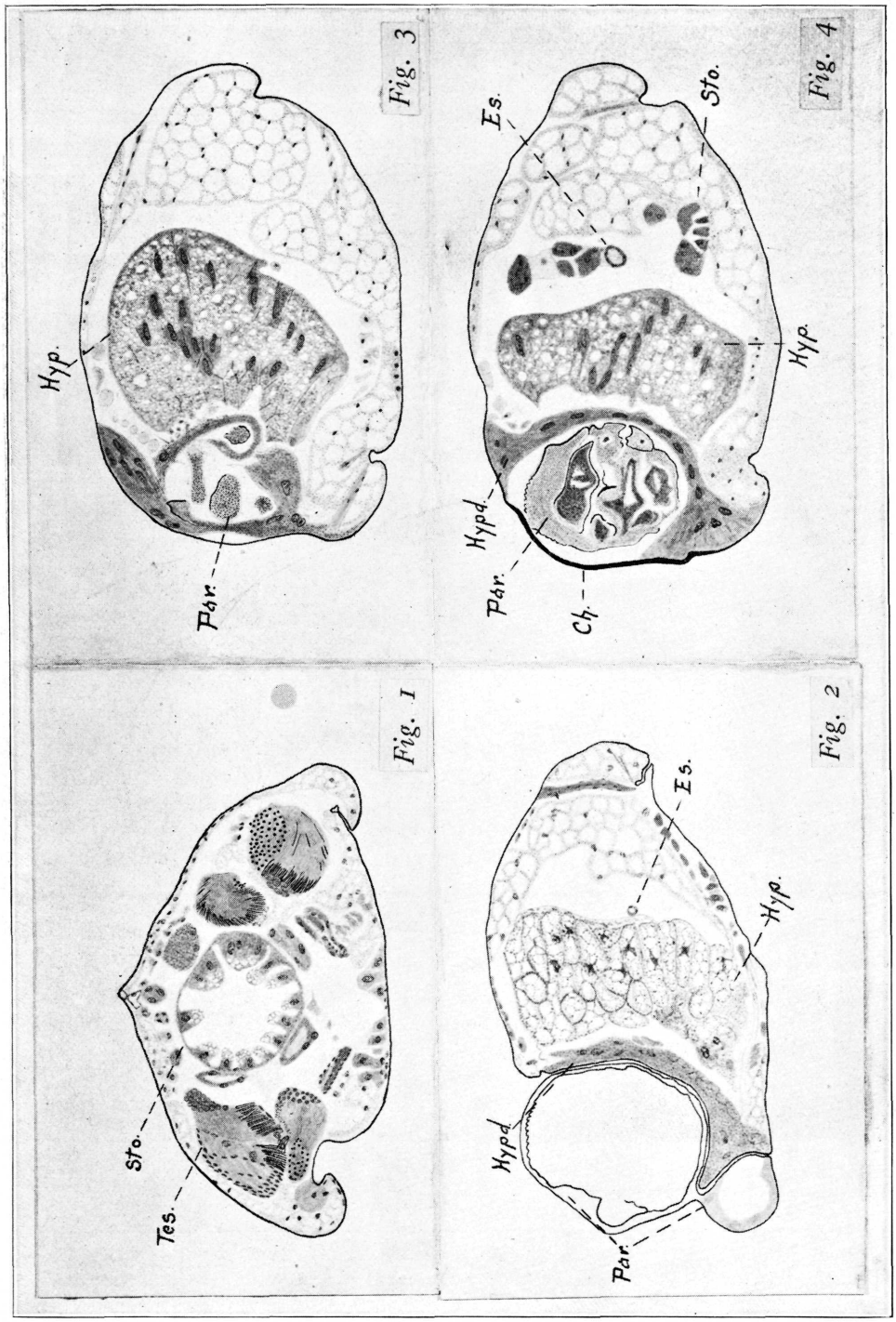
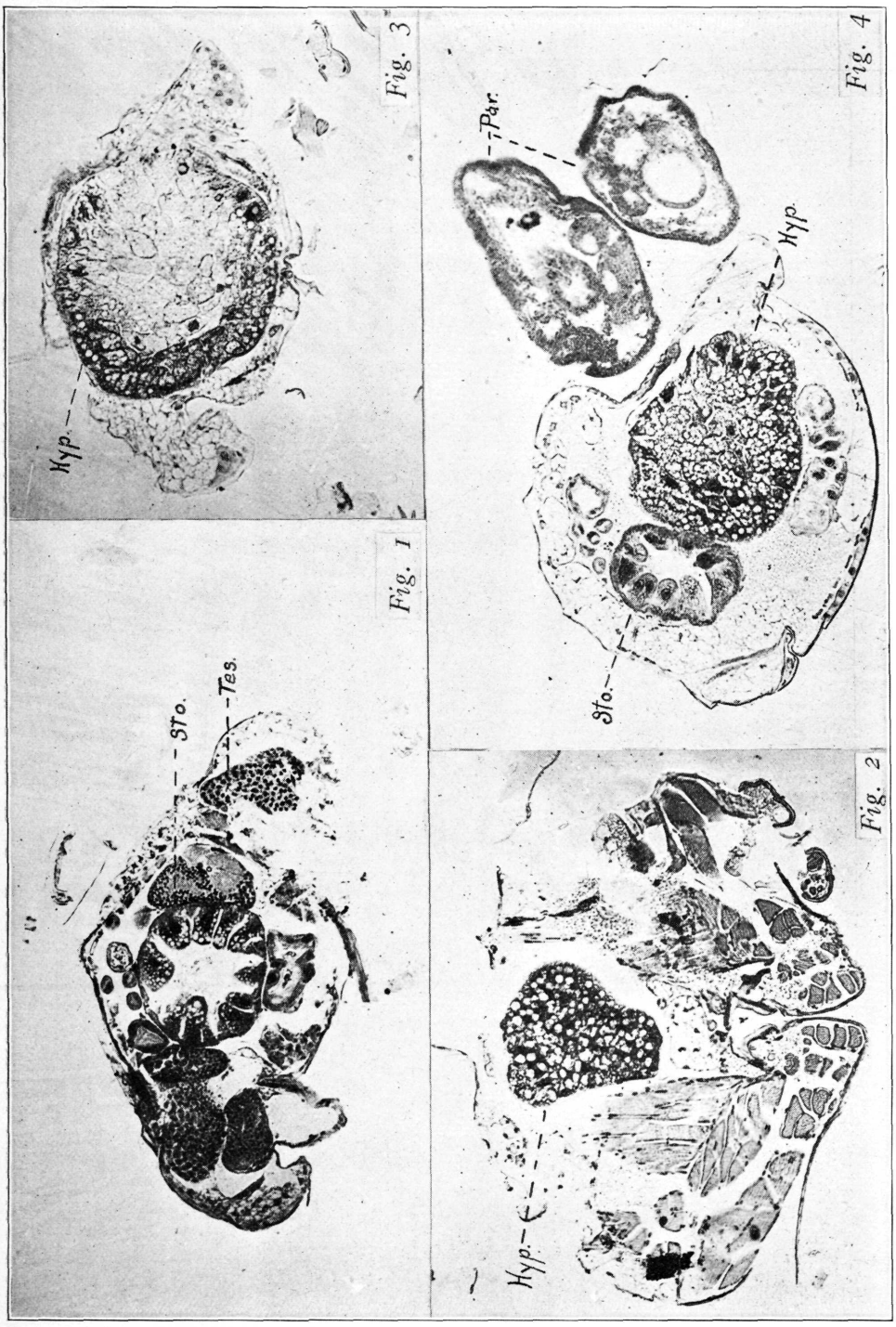


Fig. 3
Hyp.
Par.
Fig. 4
Es.
Sto.
Hyp.
Hypd.
Par.
Ch.
Fig. 1
Sto.
Tes.
Fig. 2
Es.
Hyp.
Hypd.
Par.

F. A. Fenton



F. A. Fenton

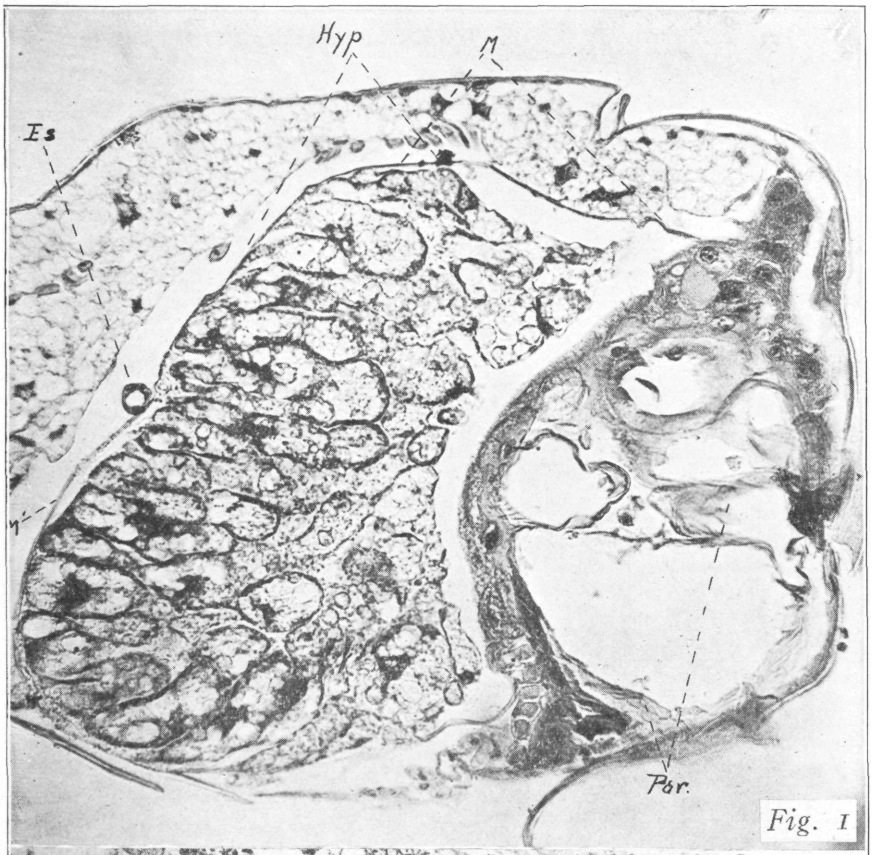


Fig. 1

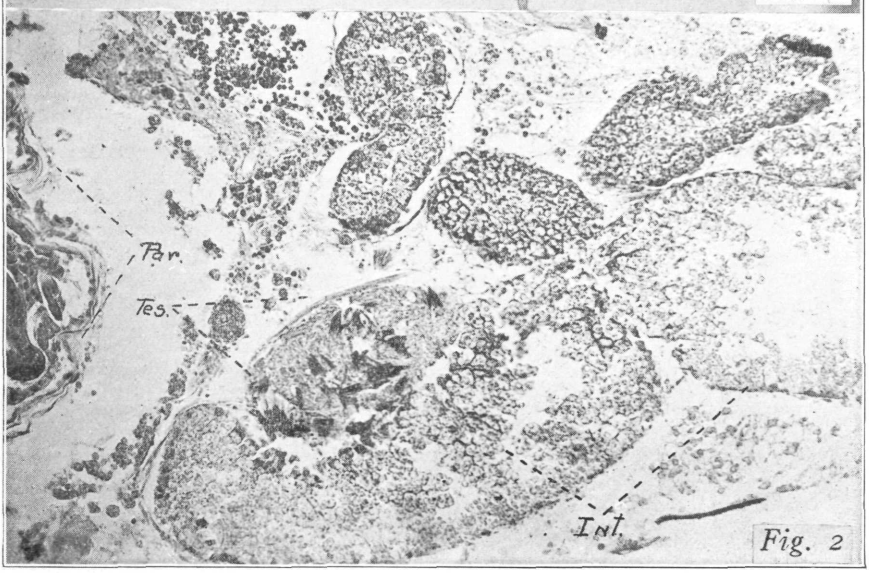


Fig. 2

F. A. Fenton